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JETTISON EVALUATION.**

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**UNITED STATES ARMY AVIATION ENGINEERING FLIGHT ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA 93523**

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The United States Army Aviation Engineering Flight Activity conducted an AH-1S jettison evaluation of the M261 19-round and M260 7-round pre-production Lightweight Airborne Launcher (LWL). The evaluation was conducted at Edwards Air Force Base, California, from 23 September to 6 November 1980. Forty-one flights totaling 11.5 flight hours were flown. The jettison characteristics of separation distance, time to clear or LWL motions did not appear to be significantly influenced by airspeed, sideslip angle or rate of descent. Satisfactory jettison envelopes for the pre-production M260 and M261 LWL were defined statically, at a hover, and in pilot perceived coordinated level flight to an airspeed of V_{H_0} and partial power and autorotational descent to an airspeed of $V_{max glider}$. The M260 and M261 LWL met the separation criteria of AMCP 706-203.		

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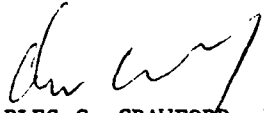
SUBJECT: Directorate for Development and Qualification Position on the
Final Report of USAAEFA Project 79-03, AH-1 Lightweight Airborne
Launcher Jettison Evaluation

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1. The purpose of this letter is to establish the Directorate for Development and Qualification position on the subject report. This test was conducted using an AH-1S (PROD) helicopter, and M260, 7-round rocket pods and M261, 19-round rocket pods. The objective of this evaluation was to develop safe jettison envelopes for the two lightweight airborne launcher models.

2. This Directorate agrees with the report, its conclusions and recommendations except that these fully successful tests justify the same jettison capability for the LWL as the current Cobra rocket pods. The concept of jettison from perceived coordinated level flight is standard procedure. When fielded, no peculiar jettison limitation will be placed on the LWL rocket pods.

FOR THE COMMANDER:


CHARLES C. CRAWFORD, JR.
Director of Development
and Qualification

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INTRODUCTION

BACKGROUND

1. The United States Army Aviation Engineering Flight Activity (USAAEFA) conducted limited jettison testing of the prototype M261 19-round lightweight airborne launcher (LWL) during 1978 under USAAEFA Project 78-10 (ref 1, app A). Based on test results, a safe jettison envelope in coordinated (ball-centered) level flight to 120 knots calibrated airspeed (KCAS) and to 70 KCAS in autorotation was established. This envelope was considered adequate for LWL development including a 7-round M260 LWL. With completion of development and production initiation, it was desirable to determine if the LWL jettison could be authorized for the same conditions as the standard rocket pods on the AH-1S Cobra. The United States Army Aviation Research and Development Command (AVRADCOM) requested that the USAAEFA conduct an AH-1 lightweight airborne launcher jettison evaluation (ref 2, app A).

TEST OBJECTIVE

2. The objective of this evaluation was to develop safe jettisoning envelopes for the production M260 and M261 LWL in level flight from hover to maximum airspeed for level flight (V_H) and in autorotative flight to the airspeed for maximum glide ($V_{max\ glide}$).

DESCRIPTION

3. The test aircraft was an AH-1S (Prod) helicopter, USA SN 76-22573. The AH-1S is a tandem seat, two-place helicopter with a two-bladed main rotor, and a two-bladed model 212 tractor tail rotor. The helicopter is powered by a Lycoming T53-L-703 turboshaft engine derated from 1800 shaft horsepower (SHP) at sea level, standard-day conditions to 1290 SHP for 30 minutes and 1134 SHP for continuous operation. The test aircraft was equipped with a nose-mounted instrumentation boom and a high-speed 16mm motion picture camera was mounted on an external pedestal at fuselage station (FS) 65 on the right side of the helicopter. A detailed description of the helicopter is contained in the operator's manual (ref 3, app A). The LWL subsystem for the 2.75 inch folding fin aerial rocket (FFAR) consists of a 7-round M260 and a 19-round M261. A detailed description of the LWL is contained in appendix B.

TEST SCOPE

4. The AH-1S LWL jettison evaluation was conducted at Edwards AFB, California. Forty-one flights totaling 11.5 flight hours were flown from 23 September to 6 November 1980. Photographic coverage was provided by the Edwards AFB photographic facility. Flight restrictions and operating limits were in accordance with the operator's manual (ref 3, app A) and the airworthiness release issued by AVRADCOM (ref 4, app A). This test was conducted to determine compliance with AMCP 706-203 (ref 5, app A). Forty-one jettisons were conducted, six each statically and at a two-foot hover, nineteen in level flight at increasing airspeeds to V_H , and ten in partial power and autorotational descent at increasing airspeeds to $V_{max\ glide}$. In-flight jettisons were made at increasing right sideslip

angles up to the sideslip angle necessary to recognize uncoordinated flight. Average gross weight was 9780 pounds, longitudinal cg at FS 194.1 (fwd), lateral cg within two inches of centerline, average main rotor speed of 324 rpm, and altitude of 3000 feet above ground level (AGL).

TEST METHODOLOGY

5. Jettison tests were conducted by stabilizing the helicopter at the desired flight conditions and then jettisoning the LWL. The inflight jettisons were conducted over the Precision Impact Range Area (PIRA) at Edwards AFB. Aircraft position on the range was controlled by ground radar. The jettison was recorded by a high-speed (400 frames per second (fps)) 16mm motion picture camera mounted on the test helicopter and another high-speed motion picture camera carried onboard a chase aircraft. Flight test data were hand recorded from calibrated test instrumentation and from standard aircraft instruments. All jettisons were made from the right inboard store station and in-flight jettisons were made using the critical rocket loading (app B). This combination was determined by an AVRADCOM analysis to be the most critical as defined by minimum separation between the LWL and the helicopter following jettison. Jettisons were initiated from both the pilot and copilot stations. All sideslips were right sideslips, the most critical. The maximum sideslip angle was the sideslip angle that would produce 0.1 g lateral acceleration. A lateral acceleration of 0.1 g has been determined as the minimum lateral acceleration necessary to recognize uncoordinated non-maneuvering flight (ref 6, app A). A detailed listing of the test instrumentation is contained in appendix C. Data analysis methods are described in appendix D.

RESULTS AND DISCUSSION

GENERAL

6. The LWL jettison evaluation was conducted to establish an expanded, safe jettison envelope for the M261 19-round LWL and to establish a safe jettison envelope for the M260 7-round LWL. During previous testing (ref 1, app A), the jettison envelope for a prototype 19-round LWL was established in a hover, in coordinated (ball-centered) level flight to 120 KCAS, and in autorotation at 70 KCAS. During this test, the static and hover jettison characteristics were found to be similar to those previously obtained so the conditions previously tested in forward flight were not repeated. The jettison characteristics did not appear to be significantly influenced by airspeed, sideslip angle or rate of descent. In all cases the closest proximity of the LWL to the aircraft following jettison was in the vicinity of the skid. Satisfactory jettison envelopes for the pre-production M261 19-round LWL and M260 7-round LWL were defined statically, at a hover, in level flight to V_H and in autorotation at $V_{max\ glide}$ at the sideslip angle necessary to recognize uncoordinated flight. The M260 7-round LWL and the M261 19-round LWL met the separation criteria of AMCP No. 706-203 (ref 6, app A).

JETTISON TESTS

Static Jettison

7. Static jettison tests of the pre-production M260 7-round and M261 19-round LWL were conducted in three rocket loadings (empty, full, and critical) with the helicopter on the ground and the engine and rotor static. Jettisons were made onto a soft surface to reduce damage to the LWL so it could be reused. A summary of LWL jettison characteristics (launcher motion and minimum separation from the aircraft) is presented in table 1, appendix D. Results of the jettison characteristics for the pre-production M261 19-round LWL were similar to those previously obtained for the prototype 19-round LWL (ref 1, app A). The LWL did not contact the helicopter. The static jettison characteristics of the M260 and M261 LWL are satisfactory.

Hover Jettison

8. Hover jettison tests of the pre-production M260 and M261 LWL were conducted in three rocket loadings (empty, full, and critical) with the helicopter at a two-foot skid height. The helicopter was faced into steady winds of less than 10 knots. Jettisons were made onto a soft surface to reduce damage to the LWL so it could be reused. A summary of jettison characteristics is presented in table 1, appendix D.) The results of these tests confirmed previous results for the prototype 19-round LWL. The minimum separation of the LWL and the helicopter skid was 1.7 inches for the 19-round LWL in the critical rocket loading and two inches for the 7-round LWL in the full rocket loading. The hover jettison characteristics of the M260 and M261 pre-production LWL are satisfactory.

Level Flight Jettison

9. Level flight jettison tests were conducted using the critical rocket loading. Twelve jettisons of the M260 LWL and seven jettisons of the M261 LWL were made in level flight. The jettison characteristics are presented in table 2, appendix D. The results show that airspeed and sideslip angle did not significantly influence the

jettison characteristics of separation distance, time to clear, jettison velocity, roll rate and direction, pitch rate and direction, or direction of yaw. The LWL cleared the helicopter on all jettisons. There were no unusual aircraft motions during or following jettison. The jettison characteristics for the M260 and M261 pre-production LWL are satisfactory in level flight to V_H at the sideslip angle necessary to recognize uncoordinated flight.

Partial Power and Autorotational Descent Jettison

10. Partial power and autorotational descent jettison tests were conducted using the critical rocket loading. Eight jettisons of the M260 LWL and two jettisons of the M261 LWL were made in partial power descent and full autorotational descent. The jettison characteristics are presented in table 3, appendix D. An airspeed of 91 KCAS was used for $V_{max\ glide}$. Jettison characteristics were not significantly influenced by rate of descent or sideslip angle. Additionally, there was no significant correlation between jettison characteristics and flight mode (level or descent). The LWL did not contact the helicopter during this evaluation. There were no unusual aircraft motions during or following jettison. The jettison characteristics for the M260 and M261 pre-production LWL are satisfactory in partial power and autorotational descent at $V_{max\ glide}$ at the sideslip angle necessary to recognize uncoordinated flight.

CONCLUSION

11. The pre-production M260 7-round LWL and M261 19-round LWL are compatible with the AH-1S (Prod) helicopter and can be jettisoned safely statically, at a hover, and in level flight up to V_H and in autorotation at $V_{maxglide}$ at the sideslip angle necessary to recognize uncoordinated flight.

RECOMMENDATION

12. The jettison envelope for the pre-production M260 7-round LWL and the M261 19-round LWL should be limited to static conditions, a hover, and in pilot perceived coordinated level flight to an airspeed of V_H and partial power and autorotational descent to an airspeed of $V_{max\ glide}$ (par 6).

APPENDIX A. REFERENCES

1. Final Report, USAAFEFA Project No. 78-10, *AH-1G Helicopter 19-round Lightweight Airborne Launcher Jettison Envelope Determination*, March 1979.
2. Letter, AVRADCOM, DRDAV-DI, subject: AH-1S Lightweight Airborne Launcher Jettison Evaluation, 23 June 1980.
3. Technical Manual, TM55-1520-236-10. *Operator's Manual, Army Model AH-1S, AH-1S (ECAS), AH-1S (Modernized Cobra) Helicopters*, 11 January 1980.
4. Letter, AVRADCOM, DRDAV-DI, subject: Airworthiness Release for Jettison Evaluation of the Lightweight Airborne Launcher (LWL) on the AH-1S Helicopter, USAAFEFA Project No. 79-03, 11 September 1980.
5. Army Materiel Command Pamphlet, AMC Pamphlet No. 706-203, *Engineering Design Handbook Helicopter Engineering, Part Three, Qualification Assurance*, 3 April 1972.
6. Study, USAASTA Project 71-03, *Pilot Perceived Jettison Envelope*, June 1973.

APPENDIX B. DESCRIPTION

TEST HELICOPTER DESCRIPTION

1. The test aircraft, USA SN 76-22573, an AH-1S (Prod) helicopter, was manufactured by Bell Helicopter Textron. A detailed description of the standard AH-1S (Prod) helicopter may be found in the operator's manual. Special equipment installed on the airframe to assist in the lightweight airborne launcher jettison test was an external camera pedestal used to secure an electrically operated, high-speed 16mm motion picture camera. This pedestal was fabricated by USAAEFA and was mounted on the right side of the helicopter at FS 65.

LIGHTWEIGHT AIRBORNE LAUNCHER DESCRIPTION

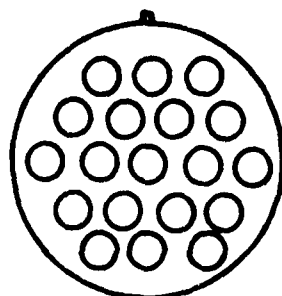
Lightweight Airborne Launcher (LWL) Subsystem

2. The LWL subsystem for the 2.75-inch rocket system consists of 7-round, M260, and 19-round, M261, sized launchers which will operationally replace the current M200A1, M158A1, and XM227 launchers. Both launchers will interface with present and developmental attack helicopter external stores systems. The launcher has a secondary role as a transportation container for a full complement of rockets that can be stored for an extended time and transported world wide as a palletized load for immediate off loading in the vicinity of the attack helicopter.

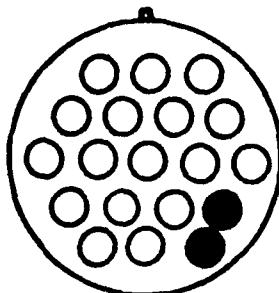
3. The LWL consists of the tube cluster, a strongback, attaching hardware, skin, forward and aft bulkheads, and structural plastic foam. The structural plastic foam is used to stabilize the launcher tube locations with respect to the structural strongback, skin, and bulkheads and to retain boresight tolerance throughout the operational life of the launcher. It is also designed to attenuate the vibrations transmitted from the attack helicopter. The launchers have electrical circuits for the firing and fuse setting pulses and incorporate a detent for retention of the rockets in the tubes during transportation and throughout the helicopter's flight envelope.

Critical Rocket Load

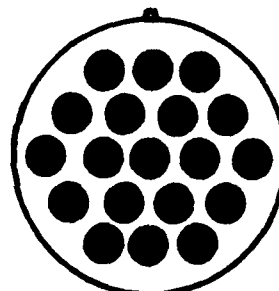
4. The loading of one rocket in tube 6 of the 7-round LWL and the loading of two rockets in tubes 13 and 7 of the 19-round LWL (fig. 1) has been determined by AVRADCOM to be the critical rocket loading. This determination was based on center of mass offset from the thrust line of the jettison system, an analysis of the flight characteristics of the LWL, and minimum separation of the LWL from the aircraft following jettison.



EMPTY

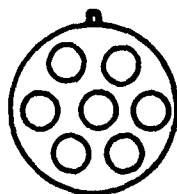


CRITICAL

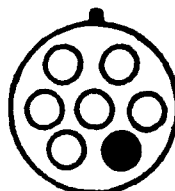


FULL

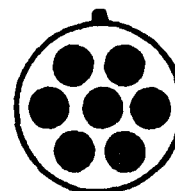
M261 19-ROUND LWL



EMPTY



CRITICAL



FULL

M260 7-ROUND LWL

Figure 1. Lightweight Airborne Launcher Test Configurations
Righthand Store Station, Looking AFT

APPENDIX C. INSTRUMENTATION

1. The test helicopter was a USAAEFA helicopter and had a boom installed extending forward from the nose of the aircraft. A swiveling pitot-static source and sideslip vane were installed on the boom. The boom system had test airspeed, altimeter, and sideslip indicators. A test fuel used totalizer was installed. All other cockpit instruments were standard. Calibration of the test indicators was accomplished by USAAEFA personnel.

2. The following parameters were displayed:

Pilot Panel

Airspeed (boom)
Altitude (boom)
Free air temperature (ship)
Rotor speed (ship)
Fuel quantity (ship)
Sideslip angle (boom)
Instrument panel lateral acceleration (turn and slip indicator)
Rate of climb (ship)

Copilot Panel

Airspeed (boom)
Altitude (boom)
Rotor speed (ship)
Rate of climb (ship)
Time (ship)
Observed air temperature
Fuel used

3. High-speed 16mm motion picture cameras were used for recording jettison data. One camera was mounted on the test helicopter with the actuation switch located at the copilot's station and the other carried by an operator aboard the chase aircraft. Camera support was provided by USAAEFA with backup provided by the Air Force.

APPENDIX D. DATA ANALYSIS METHODS

1. The analysis of the 16mm motion pictures taken during the evaluation provided the jettison characteristics of: clearance between lightweight airborne launcher (LWL) and helicopter, jettison velocity, and pitch and roll velocities. A photo analyzer capable of displaying a single frame of film at a time was used for data reduction.
2. The procedure used to compute the linear and angular velocities was to compare measurements taken from 16mm frames of film 0.025 second apart based on a standard film speed of 400 frames per second. These velocities were determined by measuring the trajectory 0.05 second after the LWL separated from the ejector piston pad. An attempt was made to correct all measurements due to change in LWL image size as distance from the camera varied.
3. The LWLs were marked in accordance with figure 1 to facilitate the analysis of jettison characteristics.

Table 1. LWL¹ Static and Hover Jettison Characteristics²

Flight Condition	LWL and Loading	Yaw Direction	Pitch Dir. Rate ³ (deg/sec)	Roll Dir. Rate (deg/sec)	Maximum Jettison Velocity (ft/sec)	Minimum Clearance (in.)	Time to Clear (sec)
Static	7-rd Empty	RT	DN 120	LT 1100	23.3	9.0	-
Static	7-rd Cnt ⁴	RT	DN 132	LT 170	19.7	4.6	-
Static	7-rd Full	RT	DN 48	LT 100	11.2	5.2	-
Static	19-rd Empty	RT	DN 84	RT 40	18.5	3.5	-
Static	19-rd Cnt	RT	DN 84	RT 300	14.4	3.2	-
Static	19-rd Full	RT	DN 36	RT 100	7.9	3.0	-
Hover ⁵	7-rd Empty	RT	DN 160	LT 1090	23.6	11.9	0.25
Hover	7-rd Cnt	RT	DN 250	N/A ⁶	N/A	N/A	0.33
Hover	7-rd Full	RT	DN 180	LT 200	10.6	2.0	0.35
Hover	19-rd Empty	RT	DN 180	RT 40	19.2	3.3	0.28
Hover	19-rd Cnt	RT	DN 150	RT 320	15.3	1.7	0.31
Hover	19-rd Full	RT	DN 90	RT 210	8.5	2.9	0.50

¹ LWL: Lightweight Airborne Launcher

² Average G.W. 9780 lbs, Average Longitudinal CG FS 194.1 (FWD)

Lateral CG within 2 in. of centerline

Main Rotor Speed: 324 RPM

³ All Jettisons from right inboard store location, all other stations clean

⁴ Rates measured 0.05 seconds after LWL separation from ejector piston pad

⁵ Cnt. Critical Rocket Loading

⁶ 2 ft hover

N/A: Not available

Table 2. LWL¹ Level Flight Jettison Characteristics²

Flight Condition	CAS ³ (kt)	Sideslip ⁴ (deg)	LWL and Loading	Yaw Direction	Pitch Dir. Rate ⁵ (deg/sec)	Roll Dir. Rate (deg/sec)	Maximum Jettison Velocity (ft/sec)	Minimum Clearance (in.)	Time to Clear (sec)
Level	70	0	7-rd Crit ⁶	RT	DN 200	LT 10	21.9	8.8	0.25
Level	65	5	7-rd Crit	RT	DN N/A ⁷	LT 60	26.5	7.0	N/A
Level	65	17	7-rd Crit	RT	DN N/A	LT 90	22.0	7.3	0.20
Level	86	0	7-rd Crit	RT	DN 270	LT 40	23.2	8.0	0.24
Level	85	5	7-rd Crit	RT	DN 370	RT 40	23.5	7.8	0.18
Level	85	12	7-rd Crit	RT	DN 270	RT 20	27.6	7.2	0.22
Level	105	0	7-rd Crit	RT	DN 320	LT 20	23.1	7.0	0.23
Level	108	5	7-rd Crit	RT	DN 470	N/A 0	24.5	8.6	0.19
Level	107	11	7-rd Crit	RT	DN 450	LT 50	24.0	8.0	0.1
Level	127	0	7-rd Crit	RT	DN 250	LT 30	21.5	9.8	0.24
Level	127	6	7-rd Crit	RT	DN 330	LT 20	24.5	8.2	0.22
Level	128	8	7-rd Crit	RT	DN 320	RT 40	23.6	8.8	0.21
Level	66	5	19-rd Crit	RT	DN 220	RT 250	17.2	1.6	0.21
Level	66	17	19-rd Crit	RT	DN 270	RT 260	18.0	2.0	0.21
Level	104	6	19-rd Crit	RT	DN N/A	RT 240	15.6	2.0	N/A
Level	102	10	19-rd Crit	RT	DN 210	RT 180	16.1	2.7	0.27
Level	126	0	19-rd Crit	RT	DN 320	RT 320	19.5	2.0	0.20
Level	125	6	19-rd Crit	RT	DN 270	RT 350	15.8	2.8	0.24
Level	126	9	19-rd Crit	RT	DN 300	RT 220	16.5	2.7	0.22

¹ LWL: Lightweight Airborne Launcher

² Average G.W. 9780 lbs, Average Longitudinal CG FS 194.1 (FWD)

Lateral CG within 2 in. of centerline

Main Rotor Speed: 324 RPM

All Jettisons from right inboard store location, all other stations clean

³ CAS: Calibrated Airspeed

⁴ Right sideslip

⁵ Rates measured 0.05 seconds after LWL separation from ejector piston port

⁶ Crit: Critical Rocket Loading

N/A: Not available

Table 3. LWL¹ Partial Power Descent and Autorotational Jettison Characteristics²

Flight Condition CAS ³ (kt)	Sideslip ⁴ (deg)	LWL and Loading	Yaw Direction	Pitch Dir.	Pitch Rate ⁵ (deg/sec)	Roll Dir.	Roll Rate (deg/sec)	Maximum Jettison Velocity (ft/sec)	Minimum Clearance (in.)	Time to Clear (sec)
Descent 700 ft/min	0	7-rd Cnt ⁶	RT	DN	320	RT	20	23.2	6.9	0.16
Descent ⁷ 1500 ft/min	0	7-rd Cnt	RT	DN	280	N/A ⁸	N/A	N/A	N/A	0.16
Auto ⁷ 2300 ft/min	0	7-rd Cnt	RT	DN	160	LT	100	20.5	7.4	0.24
Auto 2300 ft/min	5	7-rd Cnt	RT	DN	210	LT	40	23.2	7.5	0.21
Auto 2300 ft/min	16	7-rd Cnt	RT	DN	220	N/A	0	22.0	7.3	0.16
Auto 2200 ft/min	0	7-rd Cnt	RT	DN	190	LT	50	21.2	6.4	0.21
Auto 2200 ft/min	6	7-rd Cnt	RT	DN	240	LT	60	20.7	7.1	0.20
Auto 2300 ft/min	12	7-rd Cnt	RT	DN	N/A	LT	40	22.1	7.5	0.21
Auto 2300 ft/min	6	19-rd Cnt	RT	DN	180	RT	180	14.6	1.5	0.25
Auto 2300 ft/min	14	19-rd Cnt	RT	DN	180	RT	150	12.5	1.5	0.25

¹ LWL: Lightweight Airborne Launcher

² Average G.W. 9780 lbs. Average Longitudinal C.G. F.S. 194.1 (FWD)

Lateral C.G. within 2 in. of centerline

Main Rotor Speed 324 RPM

³ All Jettisons from right inboard store location, all other stations clean

⁴ CAS: Calibrated Airspeed

⁵ Right Sideslip

⁶ Rates measured 0.05 seconds after LWL separation from ejector position pad

⁷ Cnt: Critical Rocket Engine

⁸ Auto: Autorotation

⁹ N/A: Not available

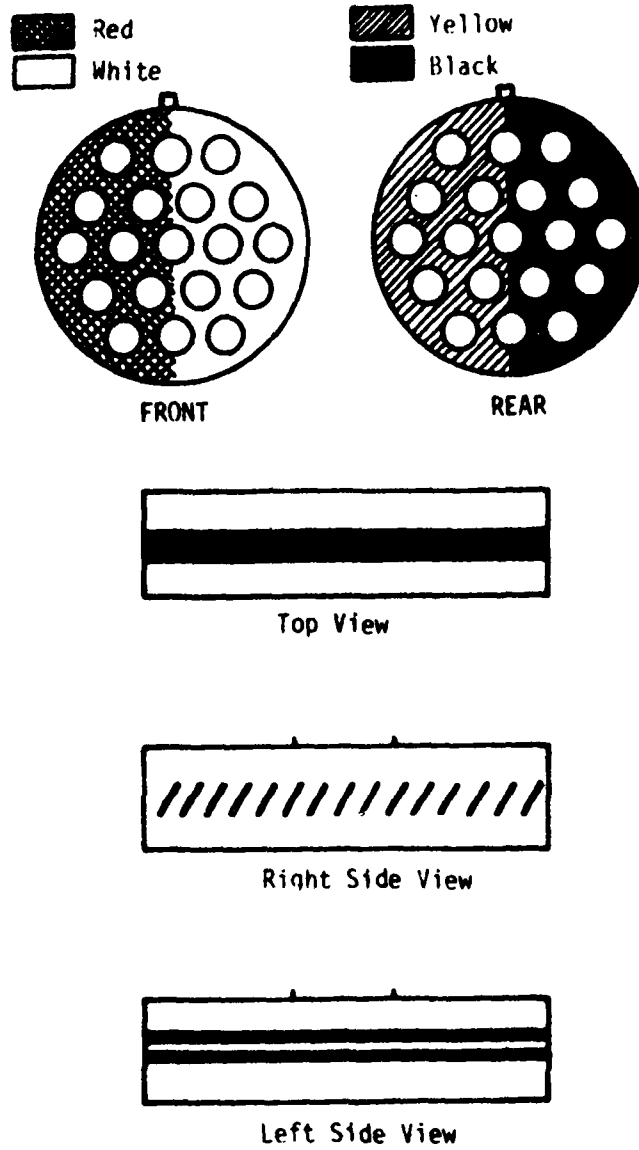


Figure 1. Launcher Markings

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US Army Materiel Development and Readiness Command (DRCDE-DH, DRCQA-E, DRCRE-I, DRCDE-RT)	4
US Army Training and Doctrine Command (ATTG-U, ATCD-T, ATCD-ET, ATCD-B)	4
US Army Aviation Research and Development Command (DRDAV-DI, DRDAV-EE, DRDAV-EG)	10
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